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An Army Discussion on Ground Vehicles and the ARC

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Agenda

- Introduction to Army Ground Vehicles
- TARDEC Strategic Thrust Areas
- Mobility and Propulsion Synergy with TARDEC
- Conclusions

Army Ground Vehicles

300,000 + **tactical and combat vehicles (150 – 1500 BHP)**

240,000 + **trucks – class 2 thru class 8 + (150 – 500 BHP)**

40,000 + **2-stroke powered vehicles (200 – 500 BHP)**

MRAP - Mine Resistant Ambush Protected

PLS – Palletized Loading System

HEMTT – Heavy Expanded Mobility Tactical Truck

*FVPDS (Jan. 2000)
Fielded Vehicle Performance Data Systems

Background - Army Ground Vehicles

COMBAT VEHICLES

- M1 Abrams (AGT-1500)
- M109/M110 Self Propelled Howitzer (8V71T)
- M2/M3 Bradley (VTA-903)
- M88 Medium Recovery Vehicle and M60 family (TCM-1790)
- M578 – Light Armored Recovery Vehicle (LRC) – (8V71T)
- Chaparral Missile Launcher (6V53T)
- FAASV – Fast Assault Ammunition Supply Vehicle (8V71T)
- M551 Sheridan Assault Vehicle (6V53T)
- Stryker (Cat 3126)
- MRAP - variants

TACTICAL VEHICLES

- HET Heavy Equipment Transporter (8V92TA)
- HEMTT Heavy Expanded Mobility Tactical Truck (8V92TA)
- PLS Palletized Loading System (8V92TA)
- 2.5 Ton Truck (LD-465/LDT-465)
- M939 5 Ton Truck (NHC 250/6CTA8.3)
- M915/M916 Line Hauler (NTC400/S-60)
- M917, M918, M919 Tractor (NTC 400)
- HMMWV (GM 6.2/6.5 IDI)
- CUCV Commercial Utility Cargo Vehicle (GM 6.2/6.5 IDI)
- FMTV (Cat C-7)

LEGEND: **black: two-stroke diesel** **red: four-stroke diesel** **blue: gas turbine**

Key Ground Vehicle Objectives

- Highly mobile
  - Transient response; high load capability; operate in high and low temperature regions; accommodate particle laden environments
  - Grade-ability; side sloping
- Survivable
  - Resist all attacks; penetrators, IEDs, EFPs, etc.
- Intelligent
  - Collect and integrate situational awareness information for decision makers
  - Unmanned vehicle use

TARDEC Strategic Thrust Areas

- Power and Energy
- Survivability
- Condition Based Maintenance
- Intelligent Systems

Future Focus for the ARC

- Power and Energy
  - complex power and energy management systems
  - high temperature operation, thermal management
- Survivability
  - Safety, rollover protection, driver training
  - advanced materials for addressing RBG and IFD threats
- Condition Based Maintenance
  - Health monitoring and prognostic capability
- Intelligent Systems
  - Unmanned ground vehicles (power/energy management, terrain interaction)

Power and Energy

Mobility and Propulsion Discussion

Army Ground Vehicle Propulsion Challenges

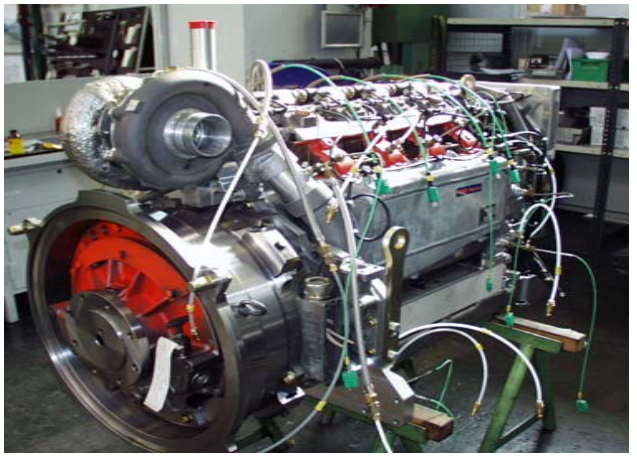
1. Cooling
2. Cooling
3. Cooling
4. Fuel Effects
5. Filtration

The Army vehicle cooling point is high tractive effort to weight under desert-like operating conditions (ex. 5 ton wheeled vehicle ~0.6 while 15 ton tracked vehicle ~0.7 both at 120 F ambient)

High Power Density Propulsion Systems

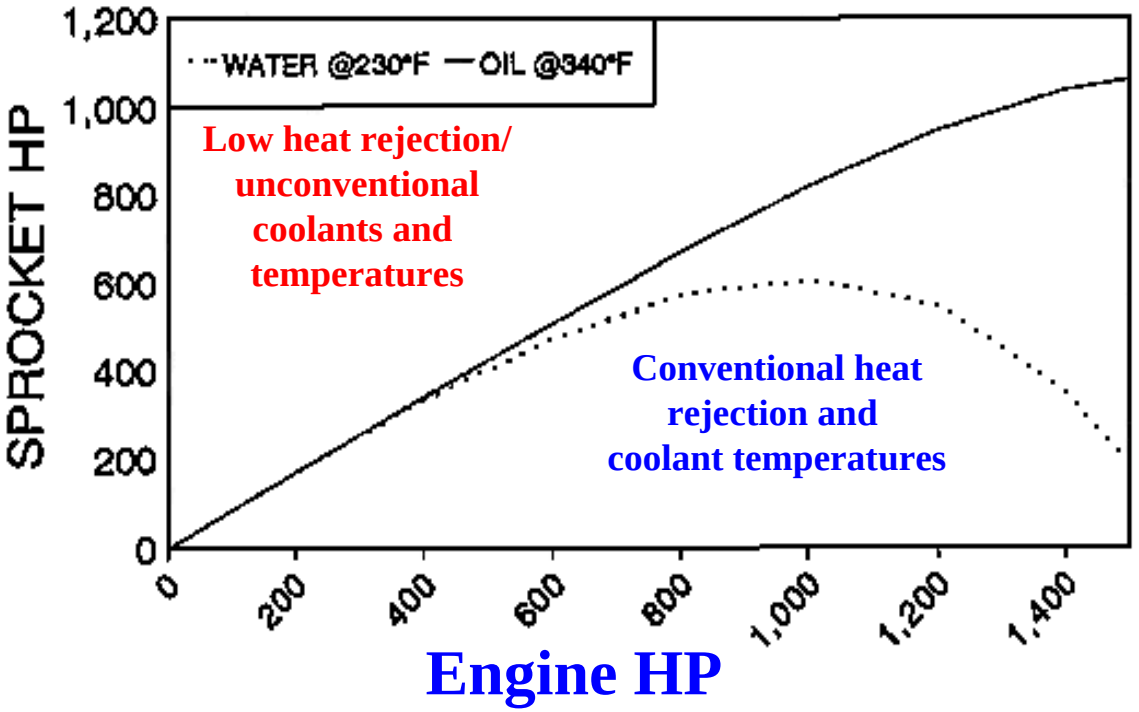
- Army definition of Propulsion System Power Density (PD):
  - PD = sprocket (wheel) power / total propulsion system volume [bhp/ft^3]
  - Air filtration requirements, thermal management system, transmission, engine (fuel), ducting requirements

Ex. Bradley FIV: PD = 3
FCS MGV target: PD = 6
Research target: PD > 8-10



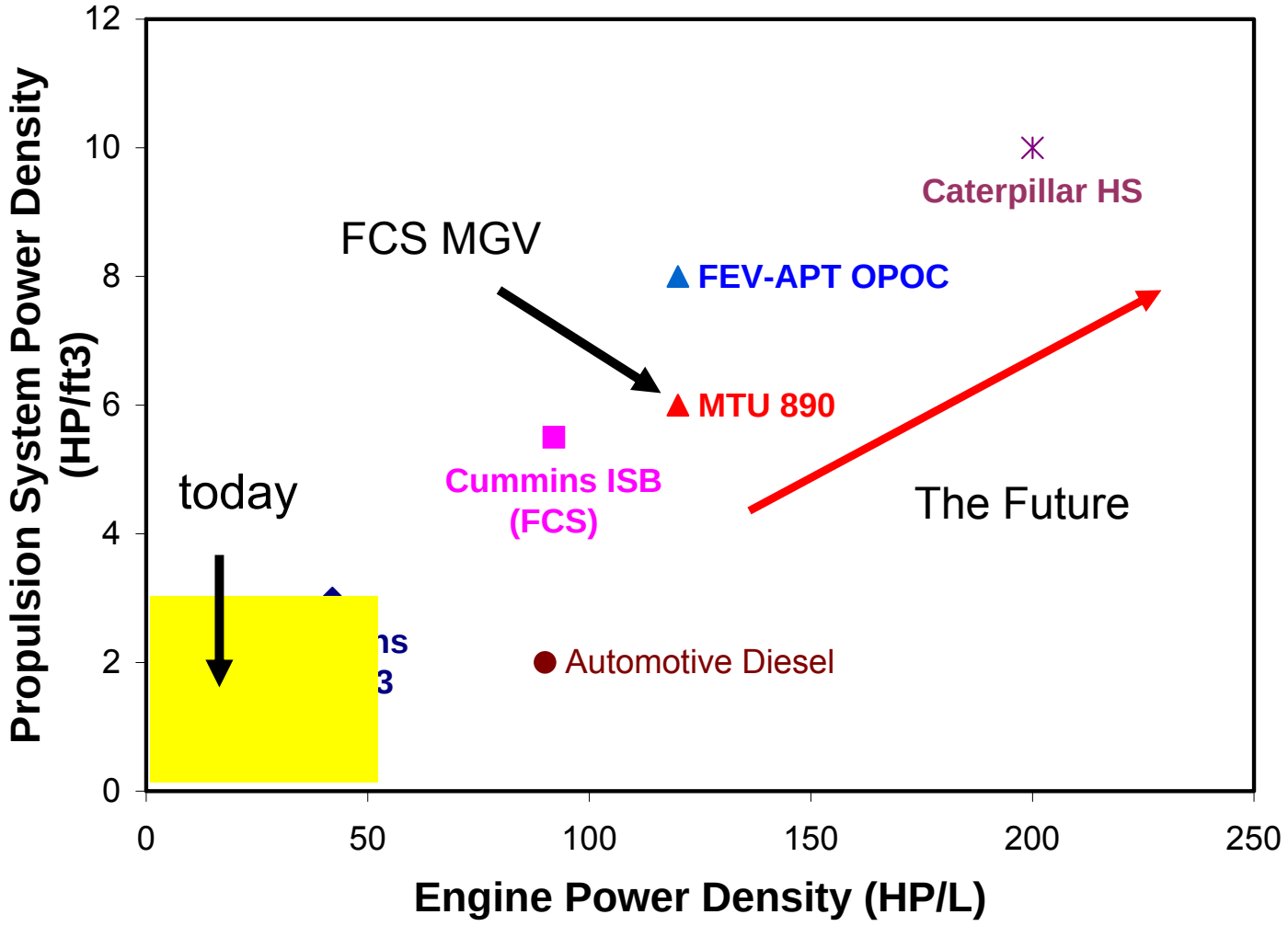
Propulsion System Power Density

Sprocket Hp vs Engine Hp
Ambient Air 120°F

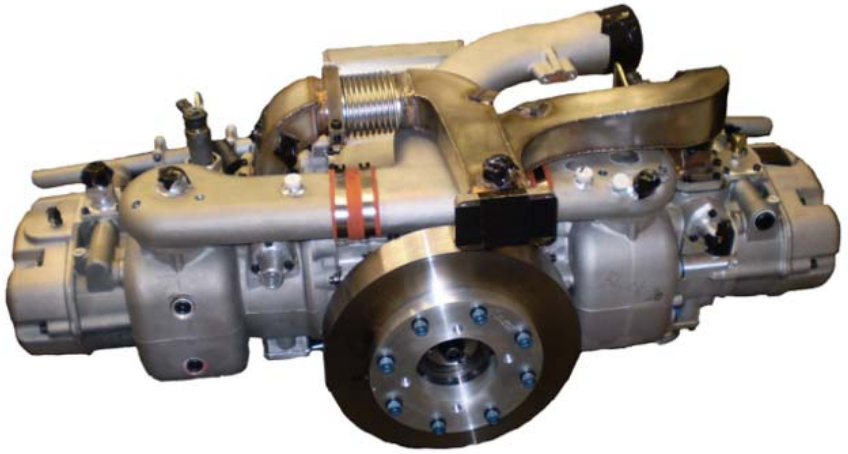


Excess fan power eats up engine power

High Power Density Military Engines



Current High Power Density Programs



High Speed Combustion Targets

- Rated speed: 6000 rpm
- Engine Power Density
  - 200 BHP/L
- Engine Heat Rejection
  - 25 BTU/bhp-min (0.6 kW/kW)

Opposed Piston Opposed Cylinder (OPOC) Targets

- Engine Power Density (125 BHP/L)
- Engine Heat Rejection
  - 18 BTU/bhp-min (0.43 kW/kW)

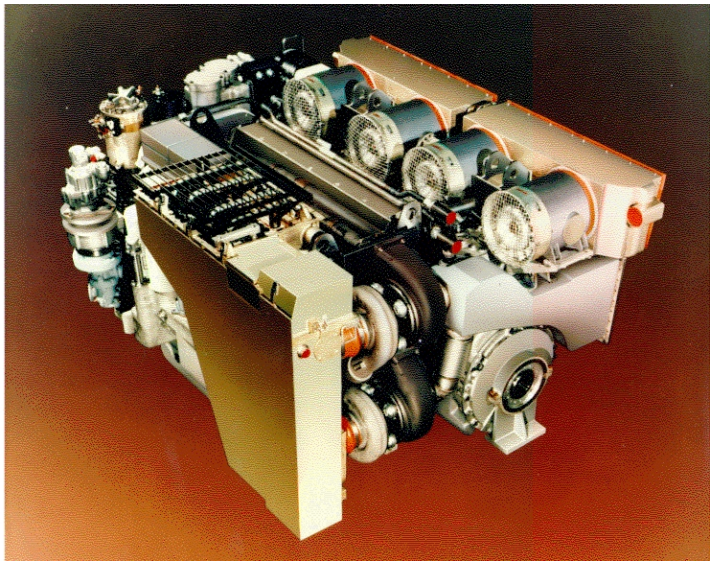
Current and Future Military High Power Density Needs

- High pressure ratio turbocharging: PR > 5

- High temperature in-cylinder package
  - Reduce CAC requirements (higher intake manifold temp.)
  - High oil sump temperatures
  - Combustion surface high temperature capability

Advanced High Pressure Fuel Injection Small Hole Combustion Study

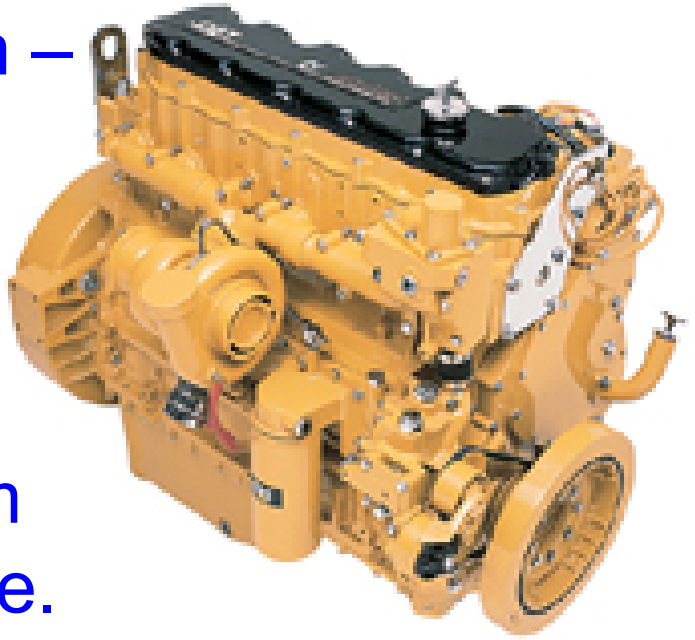
- Advanced combustion systems with multi-fuel capability (DF-2, JP-8, JP-5, Jet A, Jet A1)
  - Closed-loop in-cylinder control
  - High pressure, flexible fuel injection systems with high volumetric delivery rate
  - Push toward high load, low air-fuel ratio heat release



- Strategic and innovate cooling strategies

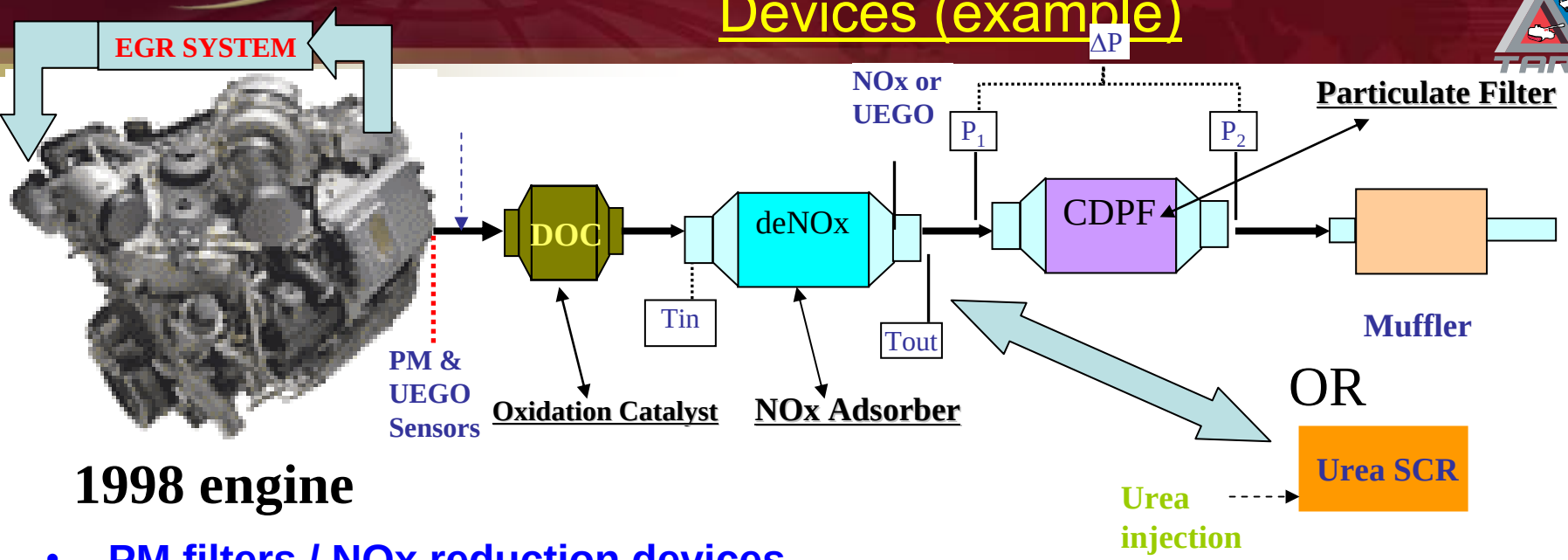
Emissions Discussion

- Combat vehicle: permanent armor/attached weapon system – National Security Exemption (NSE) via **40 CFR, 89.908**



- 'Tactical Vehicles'
  - ✓ Without ARMOR – NSE from 2004 and 2007 standards (i.e. meet 1998)
  - ✓ With ARMOR – NSE from ALL standards

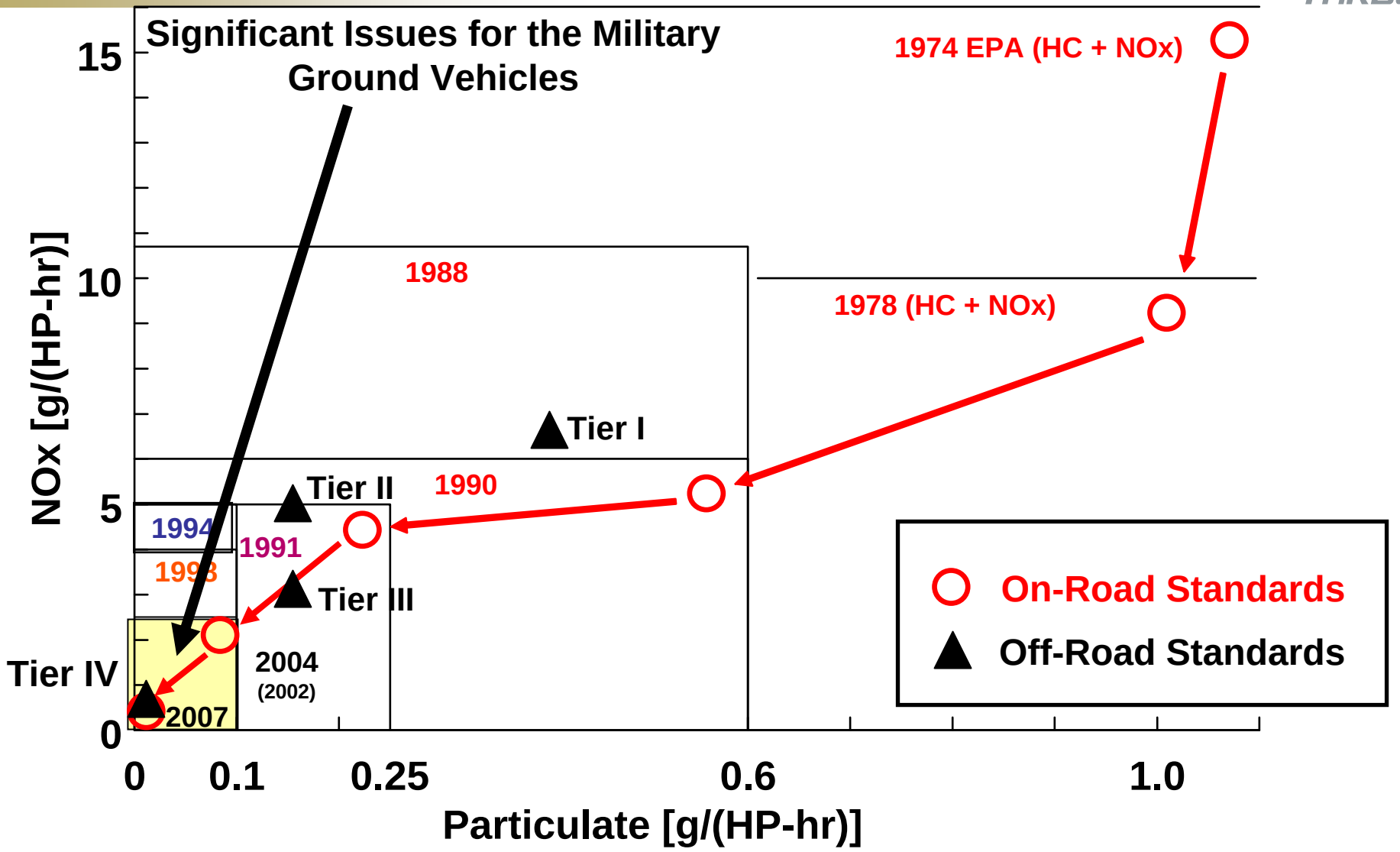
2007 (2010) Emission Issues : Aftertreatment Devices (example)



1998 engine

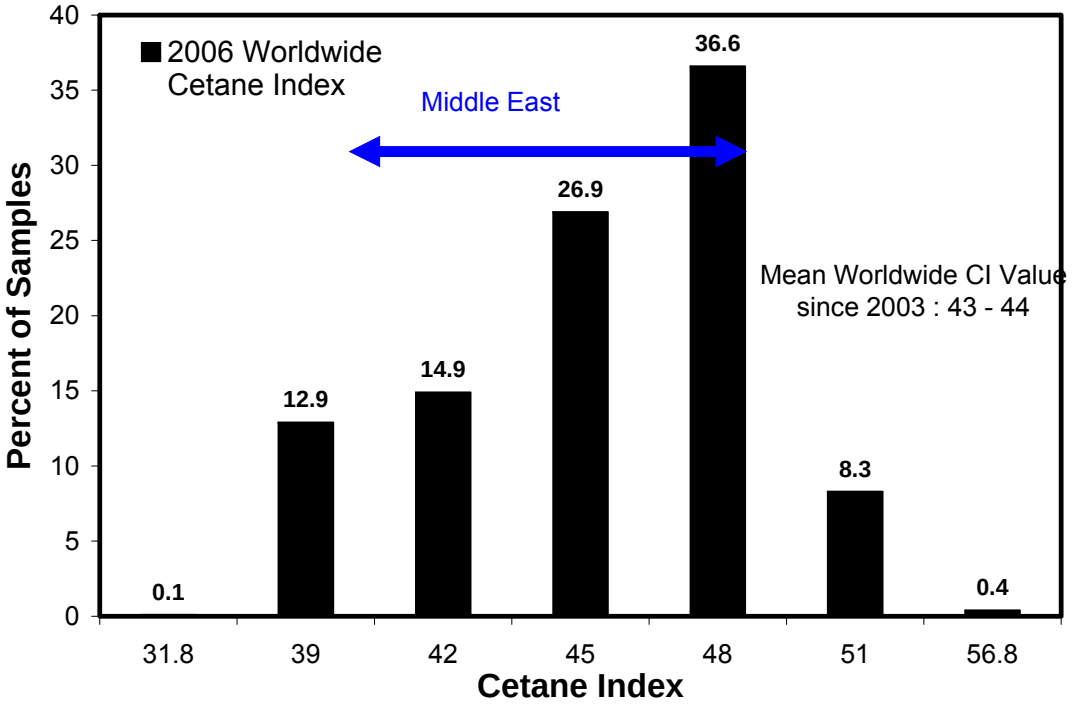
- **PM filters / NOx reduction devices**
  - ✓ Catalyzed filters (DOC + CDPF)
  - ✓ NOx trap (adsorber) vs. Urea SCR (selective catalytic reductant)
  - ✓ Additional space claim , **conservatively 5 x engine displacement**
- **NOx trap requires < 15 ppm fuel sulfur level**
- Likely to include high levels of EGR in additional to NOx aftertreatment device
  - ✓ higher heat rejection (~ 60% increase vs. MY1998)
- Oil formulation to extend CDPF lifetime
- Urea SCR requires on-vehicle, urea storage tank

Evolution of the U.S. Diesel Emission Standards

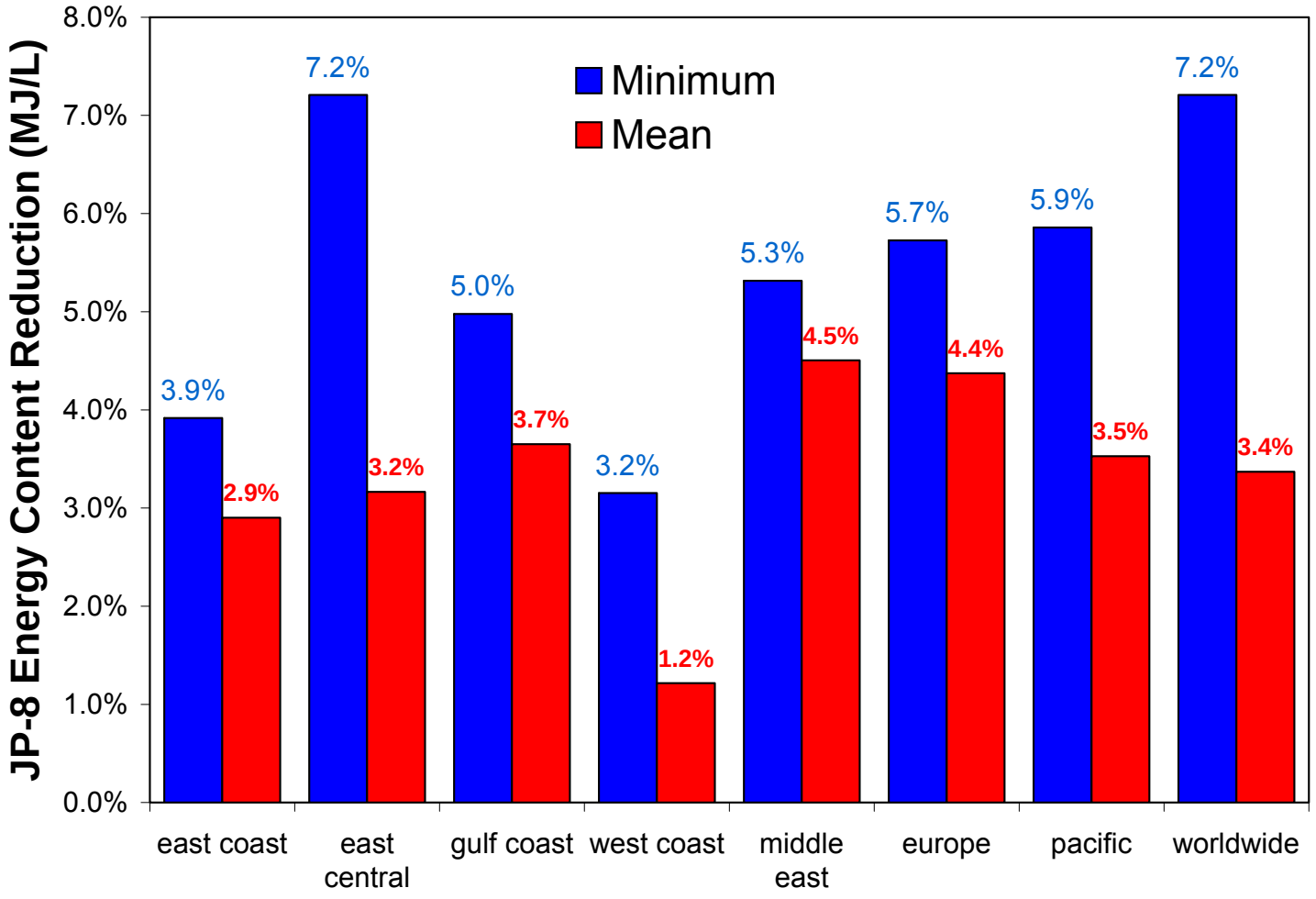


JP-8 Property Specifications

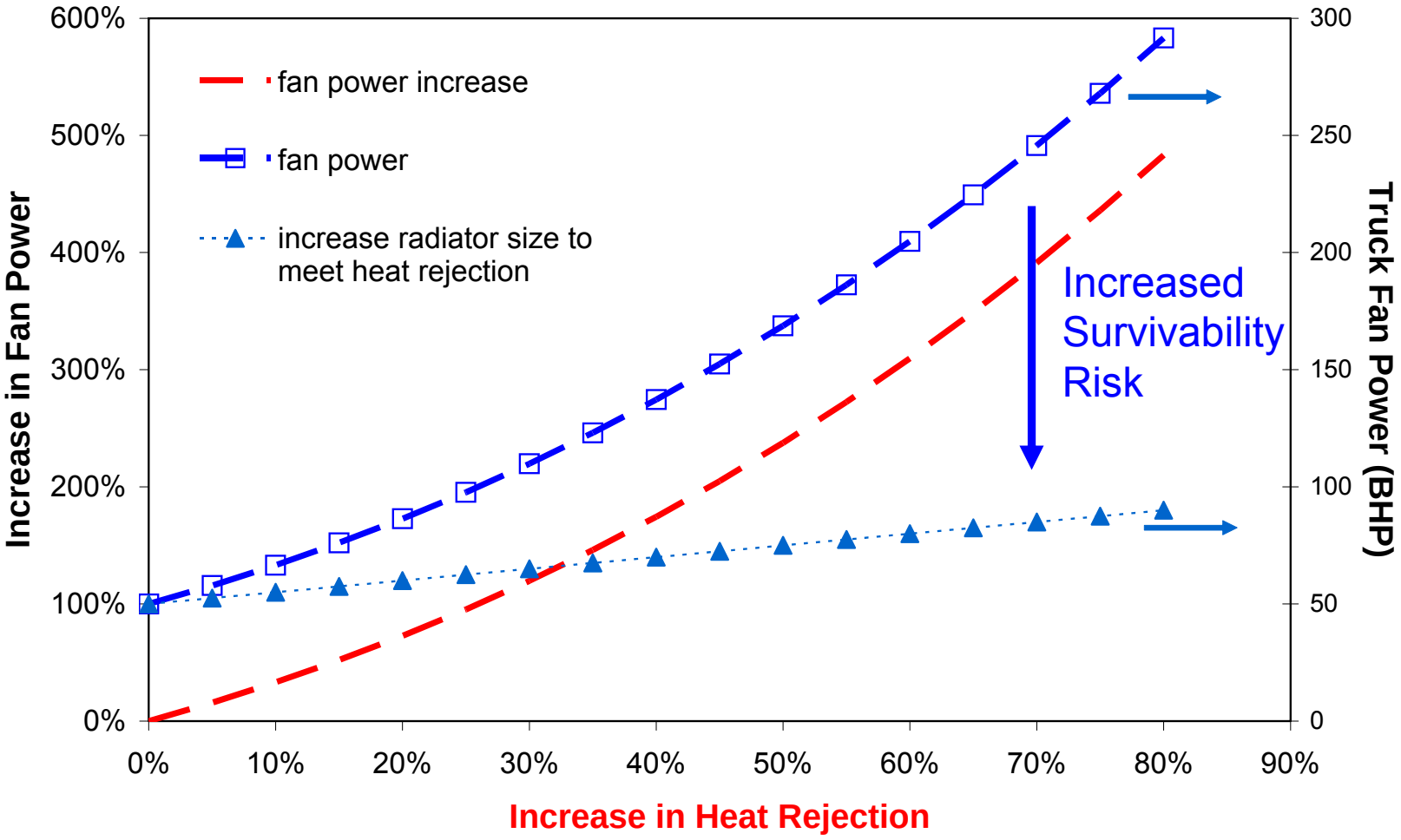
- **Sulfur content: max. 3000 ppm**
- Aromatics: max. 25%
- Specific gravity: 0.775 – 0.84
- Evaporation Characteristics:
  - 10% recov.: max. 205 C
  - End point: max. 300 C
- Net Heating Value: min. 42.8 MJ/kg
- **Cetane Index: none**



JP-8 Energy Density Question



Heat Rejection Issues



Solution Pathways

- Near term
  - Modified on-road COTS minus cooled EGR and exhaust aftertreatment
  - TIER II or TIER III engines
- Mid term
  - Modified on-road COTS and TIER IV minus cooled EGR and exhaust aftertreatment
  - Tier II or TIER III engines
- Long term
  - unknown

Conclusion

- ARC will continue to support Army and TARDEC 'needs' in key thrust areas
  - Power and Energy (Mobility)
  - Survivability
  - Condition Based Maintenance
  - Intelligent Systems

- Continual increase in focus on Power and Energy based on Army ground vehicle needs

THANK YOU!